Policies Related to Sustainable Urban Development and Urban Resilience to Climate Change

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Abstract. Cities play a pivotal role in mitigating climate change as they consume the majority of energy and contribute most to climate issues. Although municipalities create multiple sustainable policies for urban development, not all of them are effective. This article explores several guidelines for developing reasonable sustainable policies based, using case studies as a basis for analysis. Stockholm and Barcelona, two typical cities that have successfully implemented sustainable urban development policies, were selected for the study. The research employed qualitative content analysis to measure the impact of sustainable policies and identify common patterns. The findings suggest that successful sustainable urban development policies should be comprehensive, require a multi-faceted approach, and aim to reduce the city's environmental impact while enhancing its resilience to climate change. The study also highlights the crucial role of municipalities in addressing unique challenges that cities face. This research has critical implications for sustainable urban policy-making, including setting priorities to address unique challenges, promoting a sustainable lifestyle for residents, and leveraging new technologies like AI to improve the accuracy of policy-making and subsequent implementation.

Keywords: Sustainability; urban resilience; urban development; policy effects.

1. Introduction

Sustainability and resilience are quickly becoming crucial factors for urban planning. Cities are increasingly important in resolving global environmental crises since most population and economic activities are concentrated in cities [1]. Specifically, cities account for 75% of energy consumption and 80% of global greenhouse gas [2]. So, it is vitally important to tackle these climate issues by implementing policies and initiatives in the realm of cities, where municipalities play a critical role but not all of them are successful [3]. It is imperative to explore a viable pattern for sustainable urban development policy which they can take a cue from.

In the campaign against climate change, only adapting the policies to mitigate carbon emissions is insufficient. Implementing initiatives to reduce the impact of climate change on cities is also necessary and critical. The urban planning process involves two aspects of sustainability: the first is to reduce the adverse effect of cities on the environment; the second is to increase urban resilience and reduce vulnerability to climate issues [4]. And literature concerning how cities around the world deal with the worsening global climate crisis is revolutionised. The emphasis has now shifted from merely reducing vulnerability to actively boosting resilience to climate change [3]. And a new conception "resilient city" has emerged in recent years. A resilient city can be defined as a community that is in a position to confront unexpected events, tackle negative issues, and retain and develop its social, economic, and infrastructural system during uncertainty [5]. To this extent, resilience has become an interpretative metaphor for urban sustainability management [6].

Some literature describes models for sustainable and resilient policy-making. Iva M. et al. propose a model to revive planned neglected urban areas while promoting urban resilience and sustainability [7]. To pinpoint areas that require interventions to adapt and transform the system, mapping resilience can help provide valuable insights for policymakers in spatial planning processes [4]. Moreover, policies promoting urban resilience should incorporate long-term strategies, investment, and involvement of local residences and firms, and they can cover a wide range of issues [8]. These follow that sustainable policy formulation is a complicated and multi-faceted process.

Measuring policy effectiveness by urban resilience assessment is essential for modifying and optimizing policies. The assessment involves multidimensional evaluations, mostly including social, economic, ecological, and environmental dimensions [9]. Therefore, a diagnostic tool has been developed to help policymakers identify gaps in knowledge, resources, and policies that may hamper efforts to create more resilient urban environments, and ultimately lead to more effective policies and resilient cities [10]. As mentioned before, the assessment should include the effect of policies in reducing the city's environmental impact and enhancing its resilience to climate change.

This study is dedicated to identifying common patterns of sustainable policies by analyzing typical cities that have successfully implemented sustainable urban development policies. The paper is structured as follows. The next section introduces the methodology, criteria, and case selection. Section 3 describes their sustainable urban development policies. Section 4 provides data to measure the effect of those policies, compares them, and discusses their features and the reason for their success. Section 5 concludes with suggestions for further investigation.

2. Methodology

To compare and evaluate the impact of sustainable policies in different cities, it is important to choose representative cases. It is crucial to reasonably measure the effectiveness of such policies and identify successful features that promote sustainable development. This paper focuses on an empirical investigation using qualitative content analysis to identify common patterns in sustainable policies.

To make the research more persuasive and accountable, it is critical to formulate reasonable criteria for selecting typical and comparable municipalities and their policies. Specifically, they are as follows:

Design & Implementation: The municipalities must have already designed and implemented sustainable policies, which have lasted more than three years according to the long-term effect of environmental protection approaches.

Availability: Information about those policies and their consequential implementation are available from the official website and document.

Comparability: The policy effect is measured using comparable data from both pre- and post-implementation phases, across different cities.

To enhance accountability, the paper selects both cities that suffer from environmental degradation and those for becoming more sustainable and resilient. They are Stockholm in Sweden and Barcelona in Spain. Stockholm is a leader in sustainable urban development and has implemented several measures to reduce greenhouse gas emissions and energy consumption, as well as to improve air quality, biodiversity and quality of life for residents [11, 12]. Barcelona, which used to be ranked among the most polluted cities in Europe, has made great efforts in recent years and then significantly improve its environmental quality. These all exemplify municipalities' efforts in urban sustainability and resilience.

In addition, for measuring the effect of sustainable policies, this article mainly accords with the proposed indicators in an appendix in the *Environment Programme 2020–2023* adopted by the City Council on 25 May 2020 [12]. The adopted indicators are private vehicle usage, greenhouse gas emissions, air quality, and green space coverage.

3. Case Study

Sustainable policies mostly involve greenhouse gas emissions, air pollutants, resilient to climate issues, public transit, transport networks, energy consumption, and circular economy, and function in five ways: promoting energy efficiency in buildings, developing sustainable transportation, reducing and recycling waste, redevelopment of certain areas, and expanding green space. The municipality in Stockholm is mainly focused on developing sustainable transportation, creating green space, and promoting energy efficiency in buildings. While Barcelona is committed to addressing environmental issues and reducing greenhouse gas emissions. Though both cities implemented policies including

the five aspects mentioned at the beginning, they have their priority. They will be introduced as follows.

3.1. Stockholm

Stockholm is one of the most environmentally friendly cities in Europe. The municipality practised various aspects of sustainability, including sustainable transportation, waste reduction, green space, and energy saving [13]. There are two main policies for the city's ambitious engagement in sustainable development and climate resilience: The Environment Programme and The Climate Action Plan [14]. Both the policies share similar goals, and aim to achieve: a fossil-free and climate-resilient city by 2040; climate change adaptation, resource efficiency, biodiversity conservation, high air quality levels, and low noise levels in the long term; greenhouse gas emission reduction and climate-impacting consumption reduction in the short term [12, 15].

Stockholm has invested heavily in public transit, and building a comprehensive bicycle network to reduce greenhouse gas emissions [13, 15]. First and foremost, the municipality in Stockholm was committed to public transportation to reduce private vehicle usage. The government has advocated new energy-efficient vehicles which gradually were deployed in public transport, and has created interconnected bike-pedestrian networks [11, 16, and 17]. Its sustainable policies related to transport features integrating transit, a system that supports passengers in traveling on multiple types of public transit by providing integrated tickets. Additionally, as another part of the system, bike parking facilities have been well-invested at many transit stations, making it easy for cyclists to combine bike and transit trips [16]. Next, it is worth noting sophisticating infrastructure for cycling, such as bike lanes, parking facilities, and public electric scooters. One measure to promote cycling is to build physically separated bike lanes, making it safer for cyclists to travel throughout the city [17]. Besides, to restrain fossil vehicles, the municipality collaborated with the private sector to encourage electronic cars and impose a congestion tax [15].

For energy consumption, Stockholm has implemented policies mandating and supporting that buildings have a minimum percentage of their energy supplied by renewable sources [14]. It also encouraged older buildings to retrofit their energy systems with renewable energy technologies, by providing financial incentives to building owners who improve energy efficiency. Moreover, the city has also implemented a program that replaces inefficient lighting with more energy-efficient ones, such as LED lights, in public buildings.

Other effective policies Stockholm has implemented for sustainability and resilience include a comprehensive waste management system that involves sorting trash into different categories for recycling, the creation of green roofs and walls, and the expansion of public green space, such as parks and forests, to have 20% of its land covered by green spaces.

3.2. Barcelona

To tackle environmental degradation, the municipality in Barcelona initiated programs with multi-faceted approaches, including the "Superblocks" programme and the Barcelona Green Deal. Although these policies aim to promote overall urban sustainability and resilience, reducing greenhouse gas emissions and improving air quality are prioritized.

The "Superblocks" programme is the most famous and aims to create more pedestrian-friendly blocks and sustainable neighbourhoods, by segregating and combining blocks for functional specialization [18]. The most peculiar feature is the intervention of AI in the programme. AI analysed the data from detection such as air detection and traffic detection and then identified suitable areas for creating pedestrian spaces where traffic is limited to the perimeter by the municipality [19]. It also identified the urban area for redeveloping, and reconstructing energy-efficient buildings and facilities with newer technology and innovation [18]. According to AI's analysis, the municipality redistricted blocks, combining the area with similar functions, and creating convenient neighbourhoods where residents can achieve most of their needs within pedestrian or cycling distance. Additionally, detection could also provide data in real-time for AI's dynamical analysis, greatly fostering

implementation effectiveness [20]. The programme has been credited with reducing traffic, improving air quality, and increasing public space and green space [21].

Barcelona Green Deal, another important plan, aims to transform the city into a resilient economy and achieve carbon neutrality by 2050. The plan also highlights a digitised city, a city with digital infrastructure and platforms, that enhance the utilisation of buildings and spaces, optimise their performance and reduce waste. Meanwhile, digital platforms enable residents' involvement in urban sustainable development, ensuring procedural democracy. Therefore, one of the focuses is digital infrastructures in the city. Besides, regular sustainable policies including promoting energy efficiency in buildings, encouraging the use of renewable energy, improving public transportation, reducing waste for a circular economy, and facilitating green spaces and biodiversity, were mentioned in the plan [22].

4. Comparison and Discussion

4.1. The Effect of the Policies

After the implementation of The Environment Programme and The Climate Action Plan, in terms of information on the City of Stockholm's and Stockholm Public Transport Authority's official website[17,23], Stockholm has been gradually replacing old vehicles with newer, more energy-efficient ones; almost 60% of all trips taken in the city were by public transport in 2020; 1140 km of bicycle lanes have been constructed in the city, combined pedestrian and bicycle lanes, and policies have been implemented to ensure that all new construction project includes dedicated bicycle lanes; the number of trips taken by bicycle in 2020 saw a significant increase of 33%; meanwhile the number of public scooters trips increased by a whopping 80% from 2019 to 2022, compared to an increase of 6% for public transport trips over the same period; energy consumption in Stockholm's building sector decreased by 30% between 2005 and 2018[13]. Metzger and Olsson mentioned in their book that the city's waste management system has been highly successful, with nearly 40% of the city's waste being recycled [11].

According to open data provided by Barcelona City Council, air quality is significantly improved[24]: In 2022, the average annual concentration of nitrogen dioxides (NO2) in Barcelona was 29.97 μg/m3, dropping from 41 μg/m3 in 2019; Average PM10 levels have also decreased in recent years, from 25.7 μg/m3 in 2019 to 25.1 μg/m3 in 2022. About PM2.5 levels, they have seen a decrease from 15.7 μg/m3 to 13.9 μg/m3 in 2022. During 2020 and 2023[21], car trips per weekday were reduced by 19.2%; Green space increased to 19.6%; Average temperatures were reduced by 1°C; and harmful air pollutants (not limited to nitrogen dioxide) were reduced by 24.3%.

All these data indicate the success of sustainable policies and the successful governance of the municipality.

4.2. Difference and Analogy

Since the priorities of Stockholm and Barcelona and policies related to them are different, simply comparing the data is not rigorous. As mentioned above, Stockholm mainly focuses on improving sustainability at relatively high levels and resilience to climate impact, taking more climate responsibility while Barcelona is committed to addressing environmental issues, including improving air quality, reducing contaminants, and lessening its contribution to climate change by reducing greenhouse gas emissions. Both municipalities have implemented policies and initiatives with their unique characteristics. They will be discussed as follows.

In Stockholm, the municipality emphasised *cycling* as a substitution for vehicles, and then created an environment to promote residents cycling. Facilities for bicycles, cycling networks, and bike-friendly communities have been established to support routine cycling. To some extent, even public transport functions as a complement to cycling. Apart from the cycling system, *reliability and convenience* are the critical basis on which its public transport system works. Stockholm's municipality created a reliable and extensive network, with buses, trains, trams, and a subway system

operating throughout the city and its suburbs, providing frequent and punctual services even during peak travel times. Besides, Metzger and Olsson highlight *the critical role of green space* such as parks and forests, which is frequently overlooked by other municipalities, in the cities overall sustainability and resilience [11]. High green land coverage can not only significantly increase biodiversity and air quality but also improve the quality of life and well-being of residents. This is a feature that Stockholm differentiates from other cities. The environment programme details the blue-green infrastructure, which represents the basis for ecosystems and the ecosystem services the city needs, and ecosystems create healthy urban environments with cleaner water and air, less noise, and more biodiversity, a critical aspect of urban sustainability[12].

Policies and initiatives in Barcelona feature *the deep involvement of AI*. The municipality leverages AI's powerful capacities for data collection and analysis to make decisions and supervise the implementation. According to the data provided by AI, policymakers redivided blocks, resigned and redeveloped the old area to make it more sustainable, in an accurate and agile way [20]. Extensive accessible urban form data and the robust analysis capacity of AI significantly increase the accuracy and granularity of urban planning and redevelopment, and consequentially build its success in sustainable urban development. During the implementation stage, AI can also provide real-time data, enabling policymakers to adjust policies to meet the expected goals and achieve urban sustainability and resilience. It is imperative to acknowledge that Barcelona stands as the most successful municipality in leveraging AI for sustainable urban development. Other municipalities should take a cue from their efficient and accurate use of this technology.

According to the analysis, successful sustainable urban development policies should be comprehensive, mostly involving greenhouse gas emissions, air pollutants, resilience to climate issues (resilient to urban heat island effect), public transit, transport networks, energy consumption, and circular economy. However, a municipality should prioritise certain aspects related to major hurdles to the city's sustainability and resilience. Finding a way to promote a low-carbon and low-energy-consumption lifestyle for residents is important since urban people consume the most energy and are the most responsible for climate issues. New technologies like AI and digital detection can play a critical role in sustainable urban development. The practices employed by Stockholm and Barcelona serve as valuable lessons for other municipalities.

5. Conclusion

The purpose of this research is to identify effective policies for sustainable urban development by examining the strategies implemented by two municipalities, Stockholm and Barcelona that have successfully enhanced sustainability and resilience. Both municipalities have implemented comprehensive sustainability strategies, addressing public transit, energy consumption, greenhouse gas emissions, air quality, etc. However, their priorities differ depending on the distinct sustainability issues they face. Stockholm was mainly dedicated to improving urban resilience to climate impact and fostering a sustainable lifestyle. Their policies are characterised by establishing cycling networks and facilities to motivate citizens to cycle, as well as expanding green spaces to achieve a harmonious existence between humans and the environment. In contrast, Barcelona prioritised addressing environmental issues. Municipality in Barcelona features leveraging AI technology in policy-making and subsequent implementation.

This study has important implications for sustainable urban policy decisions. Sustainable policies encompass multiple aspects and require a multi-faceted approach. As noted in the introduction, these policies should not only reduce the city's impact on the environment but also increase urban resilience to climate issues. The cases highlight the importance of municipalities, which have a crucial responsibility in promoting sustainable and resilient urban development, given the unique challenges faced by cities. Success can only be achieved by prioritizing these challenges and taking decisive action. Moreover, a municipality should create an environment for promoting a sustainable lifestyle for citizens, since cities consume the majority of the world's energy and contribute most to climate

issues. In addition, leveraging new technologies like AI can significantly enhance the accuracy of policy-making and subsequent implementation by providing real-time data for adjustment.

In light of these findings, it is clear that further research is needed to analyse the failure case and explore the reason why the municipality failed to improve sustainable urban development. It is one of the limitations of this study. Structuring a reasonable model, if possible, for sustainable policy-making is also essential. Hope that this analysis will inspire further research and discussion on this important topic.

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